Mount Rainier National Park
Science Brief

National Park Service
U.S. Department of the Interior

Mount Rainier National Park

Assessing Potential Linkages Between Geohydrological Context and Macroinvertebrate Communities and Zooplankton at Habitat and Valley Scales for Ecological Monitoring

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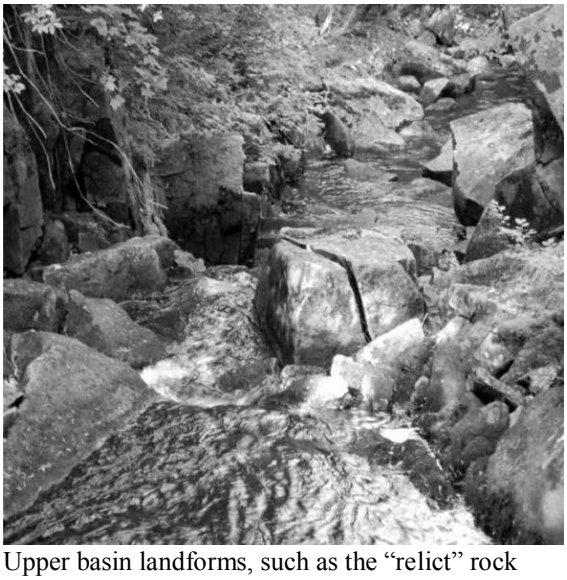
IMPORTANCE

Long term monitoring for status and trends in aquatic ecosystems requires accurate benchmarks based on an understanding of physical mechanisms that effect diverse aquatic habitats. The availability and timing of water flowing into streams, lakes, and wetlands is a critical component of the life history strategies of alpine and subalpine biota. The habitat characteristics of these water bodies appear to be dependent upon complex geohydrologic processes that are only partially understood in alpine terrains. Of particular interest from a biological perspective are the myriad sources of groundwater that are produced from ice lenses and groundwater reservoirs associated with post-glacial depositional landforms. Information about the linkages between significant groundwater sources embedded in colluvial landforms is of importance to "vital signs" monitoring efforts that aim to track changes caused by stressors such as climate change. It is also unclear how these mechanisms compare to those documented in studies performed in the Sierra Nevada and Rocky Mountains that show similar effects.



Upper basin landforms, such as the "relict" rock Glacier deposit shown in the upper photo, contribute to the characteristics of streamflow regimes downstream.

STATUS AND TRENDS

This study began as a multi-year comparison of the streamflow and water temperature regimes of five headwater basins on the east side of MORA. The streams were chosen for their similarities in drainage area, bedrock geology, climate, and topography. Our results showed that hydrologic regimes varied by an order of magnitude between the basins, a finding that could not be explained by standard parameters such as differences in drainage area. Of the five basins surveyed, Lost, Shaw, and Crystal Creeks exhibited moderated temperature and streamflow regimes associated with a significant amount of groundwater storage. In contrast, Deer and Laughingwater Creeks showed high peak flows in response to storm events and lower baseflows. These basin-wide differences in streamflow response were explained by the greater spatial extent of headwater channel length embedded within depositional landforms and paraglacial landscape features.

We then tested macroinvertebrates as indicator species in relation to colluvial and alluvial channel habitats within cirque basin headwater initiation zones. This research was intended to facilitate development of a new method to identify the hydrologic characteristics of aquatic habitat at intermediate scales. The study was based on the hypothesis that channels associated with paraglacial depositional features (e.g., steep talus footslopes with limited soil development) store and release runoff more slowly than other channel types. The study was designed to evaluate a channel segment sequence commonly found along the channel longitudinal profile in three uncontiguous cirque basins that exhibited similar paraglacial features. We used streamflow, water temperature and insect assemblage type as hydrological metrics.

Our results showed differences in insect assemblage, streamflow, and water temperature between the colluvial and the two types of alluvial channels. Temperatures did not drop below 4^0 C and above 7^0C in the colluvial channels throughout the year, while the alluvial channels registered both lower and higher temperatures depending upon the season. Streamflow regimes also varied between channel types, especially during stormflow events.

A total of 9871 aquatic insect specimens were collected during the 8 sampling weeks. Sixty-six taxa groups were used for subsequent multivariate analyses. Taxonomic richness ranged from 8 taxa in the alluvial lake inlet segment of Owyhigh Lakes basin to 28 taxa in the cascade-bedrock lake outlet of Snow Lake basin. Alluvial lake inlet segments displayed generally lower taxonomic richness among segment types in Owyhigh and Snow Lakes basins. All stream segments in Owyhigh lakes basin had lower taxonomic richness compared to the other basins. Alluvial lake inlet segments displayed lower diversity in Owyhigh and Snow Lakes basins. We collected several cold-water, spring-seep, and/or rare taxa, including mayflies *Baetis bicaudatus* (Dodds), *Cinygmula* sp., *Ephemerella alleni* (Jensen and Edmunds), stoneflies *Lednia borealis* (Baumann and Kondratieff), *Despaxia augusta* (Banks), *Setvena tibialis* (Banks), *Zapada columbiana* (Claassen), and caddisflies *Allomyia* sp., *Chyranda centralis* (Wiggins), *Ecclisocosmoecus scylla* (Ross), *Homophylax* sp., *Neothremma didactyla* (Ross), *Rhyacophila vagrita* (Milne), *R. alberta* group, and *R. rickeri* (Ross). Additionally, several *Lednia* instars were collected that aided in the description of *L. borealis* (Baumann and Kondratieff, 2010). Most of the cold-water, spring-seep, and/or rare taxa were collected in colluvial stream segment types.

DISCUSSION

The statistical analyses performed as part of this pilot study produced unusually good results. However, the both phases of the study were limited by the small sample sizes. Moreover, the study was not designed to provide a detailed analysis of the specific mechanisms that produced these results. Further work is needed to differentiate between ice and groundwater storage in common paraglacial features linked to embedded channels and contiguous lakes; answers to these questions have important hydrological implications and are urgently needed to expand understanding of long-term trends in alpine ecology, both at MORA and in other mountain regions throughout the west.

To better address the specifics of these geohydrologic processes at a fine scale, we plan to take a closer look at the interconnected geohydrologic processes found in basins such as Upper Palisades and Snow lakes. Prior gage data and landform identification suggest that they exhibit both groundwater and ice-dominated effects associated with paraglacial features. We hope to use strategic additions to the present gage network in conjunction with other tools (e.g., species assemblage surveys, stable isotope analysis, shallow seismic analysis, and ground penetrating radar) to obtain a more complete explanation of water and ice storage mechanisms and the processes linked to stream and lake hydrologic regimes.

At larger scales, we plan to compare a larger cohort of similar upper headwater basins to learn if similar paraglacial feature-channel type-species assemblage relationships are widespread. For example, many of Mount Rainier's core mountain lakes, part of the North Coast and Cascades (NCCN) "vital signs" monitoring program, are embedded within physically similar cirque basins. Lake Allen, LP19, and Blue Lake may have geohydrological attributes similar to Upper Palisades and Upper Deadwood lake basins, core mountain lakes that were also part of this pilot study. If the geohydrological processes found in the pilot study prove to be common throughout the Cascades, knowledge of these relationships will improve modeling of flow regimes downstream and allow better interpretations of trends in streamflow response due to climate change. Identification of hydrological characteristics associated with particular types of paraglacial features will also advance the interpretability of ongoing biological monitoring efforts and provide useful information that could enhance the value of park landform maps.

For more information on this topic see:

Weekes, Anne A., Christian E. Torgersen, David R. Montgomery, Andrea Woodward & Susan M. Bolton. 2012. A Process-Based Hierarchical Framework for Monitoring Glaciated Alpine Headwaters. Environmental Management Vol. 50 No. 6 50:982-997.

Kubo, J. S., Torgersen, C. E., Bolton, S. M., Weekes, A. A., Gara, R. I. (2012), Aquatic insect assemblages associated with subalpine stream segment types in relict glaciated headwaters. Insect Conservation and Diversity. DOI: 10.1111/j.1752-4598.2012.00210.x